

ZOOLOGY.—*Notes on Squilla empusa Say*.¹ ROBERT PAYNE BIGELOW, Massachusetts Institute of Technology. (Communicated by WALDO L. SCHMITT.)

The purpose of this paper is to place on record some observations made under especially favorable circumstances upon the coloration of *Squilla empusa* Say (1818), including a few notes on the behavior, external anatomy, and sexual dimorphism of this stomatopod crustacean, the only one found normally in the vicinity of Woods Hole, Mass.

Squilla empusa is known to range southward to the Gulf of Mexico and Texas. It has been found also in the West Indies and has been reported from west Africa. Buzzards Bay appears to be the northern limit of its distribution, and, while the pelagic larvae are occasionally abundant in the plankton, adults are rarely taken (Sumner et al., 1911). Only a few specimens are brought into Woods Hole from time to time by scallop, *Pecten (Plagioctenium) irradians* Lamarek, or quahaug, *Venus mercenaria* Linnaeus, fishermen. In September 1931, however, a number of half-grown specimens were taken with the seine in the Wareham River; and on several trips made between the first of August and the last of September 1932, large numbers of adults were captured by Robert A. Goffin, of the U. S. Fisheries Biological Station, with a shrimp-trawl in Mattapoisett Harbor and in Wareham River, on the north shore of Buzzards Bay.

Although in Woods Hole at the time, I was unaware of these events until—just as I was about to leave—my attention was called to an exhibit in the public aquarium room of the Fisheries Station. In a big glass aquarium, close by a large window of frosted glass, were 21 adults selected from some hundred specimens taken by Mr. Goffin with the otter shrimp-trawl at a depth of about 3 fathoms in Mattapoisett Harbor on September 6, 1932. The specimens were lively and in excellent condition, visible from all sides, and brilliantly illuminated by diffused sunlight during the morning hours. Their coloration was striking. This is a feature usually neglected in taxonomic works (cf. DeKay, 1844; Bigelow, 1895; Pratt, 1916), and here was an opportunity not to be missed. As the time at my disposal was short, I made careful notes without waiting to consult the literature. Thus my observations were made independently of the detailed but rather incomplete descriptions of Say (1818, p. 252) and of Verrill and Smith (1873, p. 369), and for that reason, perhaps, they may be worthy of record.

¹ Received April 14, 1941.

COLOR PATTERN

As seen in the aquarium, the animals were ornamented on the dorsal side by a ground color and by markings in various other colors that produced a brilliant pattern. The ground color was an opalescent purple—described by another observer as “mauve,” or gray with a tinge of violet. Across the median area of the somites of the hindbody were transverse shadowy gray patches, most marked on the second abdominal somite.

Aside from these indistinct patches, the markings were mostly green, opaque white, yellow, and orange. The green color marked the projecting portions of the integument. On the posterior border of the carapace and of each somite of the hindbody there was a band of apple green shading anteriorly into a deep olive-green. The bright-yellow edge mentioned by Say and by Verrill accentuates the light green on the margins of the carapace and the last two abdominal somites. Except for the marginal carinae of the abdomen, each carina, from the rostrum to the telson, and the basal bosses of the marginal teeth and denticles of the telson were marked by green in the same way. On the dorsal surface of the telson each one of the pits on each side of the crest appeared as a light-green spot. Also the dorsal carina on the propodus of the raptorial limb is light green, while the margin of the ventral groove of the merus is purple, the two colors coming close together when the claw is closed.

The opaque white markings on the body consist of fine lines and spots in a symmetrical pattern on the submedian area of the thoracic and abdominal somites, and of large irregular patches lateral to the intermediate carinae of the thorax and of the abdomen and between the lateral and marginal carinae of the abdomen, extending to the flattened surface of the marginal carinae. The mobile spines of the uropods are entirely white, and the same color appears on the tips of the submedian and intermediate teeth of the telson and of the prongs of the basal process of the uropods, and along the outer margins of the pleopods. The thoracic limbs are pinkish white.

The antennal scales are yellow toward the apex, while a deeper yellow marks the outer half of the paddle of the uropods. The color scheme is completed, in the main, by broad fringes of setae that border the antennal scales, the pleopods, and the uropods. These are a shade of orange that forms a strong contrast to the other colors.

The eyes are among the most striking features of these animals. Both Say and Verrill describe them as brilliant emerald-green. In our specimens the outer layers of the cornea were perfectly transparent,

and within could be seen a dark mass with a brilliantly iridescent metallic luster. The eye stalks were translucent with a pinkish or orange hue.

If this more detailed description is compared with that of Say or of Verrill and Smith, it will be found to differ in many particulars. It differs fundamentally from the description and figure of DeKay (1844, p. 33, fig. 54).

It is well known that some Crustacea change color with a change of background (Keeble and Gamble, 1904; D. C. Smith, 1930; F. A. Brown, 1935). Late in the summer of 1933 it was suggested to me that *Squilla empusa* may be one of the variable species. To test this an attempt was made to obtain material for experiments, but a day of strenuous dredging, September 14, yielded only one specimen where the species had been abundant the year before. Without an ample supply one could not expect significant results. Nevertheless, this one large female was subjected to a series of experiments with apparatus kindly lent by G. H. Parker at the Marine Biological Laboratory, and no change in color was observed. That result is perhaps to be expected of an animal that spends part of its life in a burrow. If there is any change, it may be very slow, as in the crayfishes (Kent, 1901).

BEHAVIOR

While notes were being made of the color the animals were constantly in motion. Even those that were resting on the bottom exhibited rhythmic, fanlike movements of the epipodites on the first five pairs of thoracic limbs. These movements of the epipodites were not in phase with the similar rhythmic motion of the gill-bearing abdominal appendages, the pleopods. It was amusing to observe the use that frequently was made of the first thoracic limb to clean the body. By means of the brush of setae on the terminal segment, first the adjacent limbs were thoroughly scrubbed, then the body was bent so that other parts could be reached, until finally a complete toilet had been accomplished, including all the abdominal appendages and gills.

Locomotion on the bottom was by alternate movements of the three pairs of thoracic walking legs; but change from place to place was chiefly by swimming with progressive oarlike strokes of the pleopods. Occasionally a sudden backward movement was made by a powerful flexure of the hindbody. Application of the net handle to the antennules of a resting individual evoked a stroke of the raptorial claws that was startling in its swiftness and force.

There were small fishes in the aquarium. They were frequently pursued. The capture was observed of a menhaden about 5 cm in length. This was accomplished by bilateral grasping movements of the raptorial limbs. The fish was quickly bitten cleanly in two. The posterior half dropped to the bottom. There it was found and eaten by another squilla while the captor was consuming the other part.

STRUCTURAL FEATURES

Opportunity to supplement previous descriptions of the structural features of this species is afforded by the courtesy of Mr. Goffin, who placed in my hands two males (76 and 145 mm) and three females (97, 105, and 180 mm) preserved from the catch of September 6, 1932; and also a male (150 mm) taken with a scallop-dredge in Buzzards Bay at North Falmouth in November 1926.

The facts to be recorded are in two groups—first, referring to the affinity of this species to other species of the genus; and, second, relating to sexuality.

In the first group should be noted the presence of mandibular palps with three segments; epipodites at the bases of all of the first five thoracic limbs; and an abdominal spine-formula (Kemp, 1913, p. 9), as follows:

<i>Carinae ending in spines</i>	<i>Abdominal somites</i>					
Submedian.....					5	6
Intermediate.....			(3)	4	5	6
Lateral.....	(1)	2	3	4	5	6
Marginal.....	1	2	3	4	5	

The carpus of the raptorial limb, when fully developed, bears a dorsal crest with four sharp teeth, the distal one out of line with the others. The exopodite of the uropods is armed with 8 or 9 (rarely 6) mobile spines, the distal one acute, not greatly elongated, and curved toward the apex of the limb.

SEXUAL DIMORPHISM

Of special interest are the differences in the sculpturing of the telson and the abdominal somites to be seen by comparing young with old of both sexes and fully grown males with females of the same age. These differences were well marked in the six specimens examined at Woods Hole. In the two smaller females and the small male the crest and marginal carinae of the telson have sharply defined summits; and the marginal carinae of the abdomen, separated by a distinct groove from the edge of the somite, are but slightly wider than the other carinae and each one is distinctly grooved longitudinally. In the large

female (180 mm) and the two large males (150 and 145 mm in median length) the sculpturing of the telson is alike and differs from that of the smaller specimens in having the crest and marginal carinae swollen and broadly rounded at the summit.

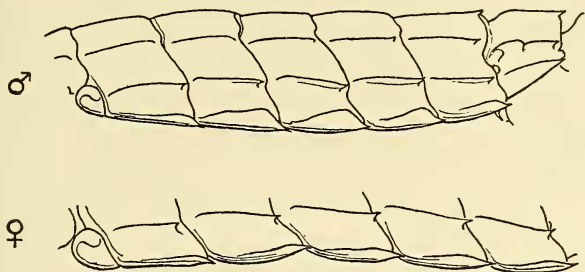


Fig. 1.—*Squilla empusa*: Six abdominal somites of a male 150 mm long and lateral and marginal carinae on the abdomen of a female 180 mm long. Left lateral aspect, natural size.

On the other hand, the marginal carinae of the abdomen in these large individuals exhibit distinct sexual differences, as shown in Fig. 1. On the third abdominal somite of the large female these carinae are grooved on the anterior third of their length and the posterior two-thirds is broad (about one-tenth the length) and distinctly swollen. This feature is progressively less marked on the other somites toward each extremity of the abdomen. The two large males differ from the female in having these carinae very much broader (maximum width about one-fourth the length) with the summit a broad flat plane—not at all grooved, except slightly on the first abdominal somite.

Thus our species shows distinctly in one feature, previously overlooked, some of the sexual dimorphism, that is conspicuous in several closely related species of the Panama region.

REFERENCES

- BIGELOW, ROBERT P. *Report on the Crustacea of the order Stomatopoda collected by the steamer Albatross*. Proc. U. S. Nat. Mus. 17: 525-534. 1895.
- BROWN, F. A., JR. *Color changes in Palaemonetes*. Journ. Morph. 57: 317-333. 1935.
- DEKAY, J. E. *Zoology of New York, Part 6, Crustacea*, pp. 32-33, pl. 13, fig. 54. 1844.
- KEEBLE, F., and GAMBLE, F. W. *Colour-physiology of higher Crustacea*. Phil. Trans. (B) 196: 295-388, pls. 18-23. 1904.
- KEMP, STANLEY. *Crustacea Stomatopoda of the Indo-Pacific region*. Mem. Indian Mus. 6. 1913.
- KENT, W. J. *Colors of the crayfish*. Amer. Nat. 35: 933-936. 1901.
- PRATT, H. S. *Manual of the common invertebrate animals*, p. 384. 1916.
- SAY, THOMAS. *An account of the Crustacea of the United States (Continued)*. Journ. Acad. Nat. Sci. Philadelphia 1: 250-253. 1818.
- SMITH, D. C. *Effects of temperature changes upon the chromatophores of crustaceans*. Biol. Bull. 58: 193-202. 1930.
- SUMNER, F. B., et al. *Biological survey of the waters of Woods Hole and vicinity*. Bull. U. S. Bur. Fisheries 31: 137, 662. 1911.
- VERRILL, A. E., and SMITH, S. I. *Report upon the invertebrate animals of Vineyard Sound and adjacent waters*. U. S. Fish Comm. Report for 1871-72, pp. 369, 536, 551. 1873.